

# Scientific Progress and Recommendations from the International Volcanic Ash Task Force



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- **IVATF was formed by ICAO in response to severe disruptions to air travel during Eyjafjallajökull's 2010 eruption.**

- >100,000 flights cancelled; >300 European airports closed.
- 7 million passengers unable to travel for 6 days in April 2010.
- \$1.7 B USD in loss of revenue to airlines (per Oxford Economics).



- **IVATF brought together stakeholders from civil aviation authorities, VAACs, equipment manufacturers, airline industry, pilot groups, and scientific groups from around the world.**

- Existing ICAO group that deals with ash—IAVWOPSG—has smaller membership.

### **IAVTF Looked at:**

- How best to manage air traffic in the vicinity of ash clouds (i.e., alternatives to closing vast stretches of airspace).
- How best to detect ash in the atmosphere.
- How best to forecast expected cloud movement and longevity.
- How to establish engine and airframe tolerances.
- How best to define and warn of hazardous airspace.



- **Met 4 times in Montreal, ending its work in June 2012. All documents and final report available online—search on “IVATF”**

# Strong Science Input to IVATF

- From the start, ICAO recognized the need for scientific guidance on best methods to detect, forecast, and warn about ash clouds.
- A specific IVATF **Science Subgroup** was formed to make sure that IVATF decisions and recommendations had a sound scientific basis.
  - 1 of 4 subgroups; others were Air Traffic Management, Airworthiness, IAVW Coordination.
- The Science Subgroup sought input from the global scientific community primarily through the **Volcanic Ash Scientific Advisory Group (VASAG)**, established by the WMO in 2010 to advise ICAO on the scientific basis for operational ash-hazard issues.
  - Andrew Tupper and Larry Mastin are co-chairs of VASAG.
  - Marianne Guffanti was Project Manager of IVATF Science Subgroup.
  - Peter Lechner served as Chair of the IVATF and is Chair of the IAVWOPSG.
  - Raul Romero is Secretary of ICAO's long-standing IAVW Operations Group.

# Broad Scope of “Science Subgroup”

## 6 “Tasks” – most of them pertinent to this workshop:

- Determine ways and means to improve **volcanic cloud detection** and avoidance systems.
- Determine ways and means to improve **situational awareness of impending eruptions**.
- Support efforts to establish aircraft “**airworthiness**” criteria.
- Identify technologies and systems to improve **eruption source parameters** for dispersion modelling.
- Advise on methods of **dispersion model** improvement and validation.
- Advise on volcanological and meteorological aspects of exposure of aircraft occupants to **SO<sub>2</sub>**. (added late)

# Overall Scientific Progress

- Within the IVATF structure, the Science Subgroup and VASAG contributed 22 papers addressing the 6 tasks.
- Outside the IVATF structure, numerous workshops held by scientific and aviation groups. Government and academic scientists redirected or accelerated research on volcanic clouds.
  - A burst of peer-reviewed scientific publications, including in Special Issues of ACP, JGR, AE.
  - More government funding for volcanic cloud research (mostly in Europe).
- Overall, substantial progress has been made, for example:
  - airborne in-situ sampling of volcanic clouds.
  - use of lidar (ground-based, airborne, space-based) to detect and characterize volcanic clouds.
  - quantitative retrieval of ash-cloud microphysical properties from satellite data.
  - combining satellite data and dispersion modeling.
  - and much more....

# General IVATF Recommendations: Future Research Directions

- Characterizing volcanic plumes at/near the source
  - Forecasting explosive eruptions, observing ash production and estimating ESP, modelling plume structure and dynamics, relating properties of ash in deposits to ash in clouds.
- Understanding evolution of volcanic clouds in time & space (in terms of cloud shape, composition, density, longevity)
  - Quantitative methods to estimate microphysical properties of volcanic clouds from satellite and ground-based observations.
  - Process of particle aggregation as it affects ash fallout rates.
  - Rapid, reliable methods to assimilate observational data into dispersion model runs.
  - Ensemble techniques to quantify uncertainty in the output of dispersion-model forecasts.
  - Creation of quality-assured and detailed observational databases for rigorous evaluation and further development of dispersion models.
- Further analysis of hazard impacts
  - Additional studies of ash/aircraft encounters; engineering investigations of effects of ingestion of volcanic ash and gas on aircraft.
- Improving observational capabilities globally
  - Volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and airborne sampling.

# Specific IVATF Recommendation

## —Definition of “Visible Ash”

Guidance to pilots is “avoid visible ash” which raised many questions:

- Does visibility equate to a single concentration value (e.g., 2 mg/m<sup>3</sup>)? (No – orders of magnitude variation!)
- If you look up/out and see blue sky, is there no ash? (Not necessarily)
- Are remotely sensed clouds visible to the human eye? (Not always, not completely)



- **Visible Ash** = ash observed by the human eye. Not defined quantitatively at the time of observations. What is *actually* observed, not “would be, could be, should be” observed.
- **Discernible Ash** = ash detected by (1) impacts on aircraft or (2) by in-situ and/or remote-sensing techniques.
- **Corollary:** VAACs do not forecast visible ash. VAAC “best practice” is to define cloud primarily based on satellite data whenever possible, then forecast (model) where that cloud will go. So they essentially are forecasting “discernible ash.”
- **VASAG guidance on quantifying discernible ash:** for current infrared satellite sensors, lower detection threshold for *mass loading* is 0.2 g/m<sup>2</sup> ( $\pm$  0.150 g/m<sup>2</sup>) under favorable conditions. For cloud thickness of 1 km, that equates to 0.2 mg/m<sup>3</sup>.

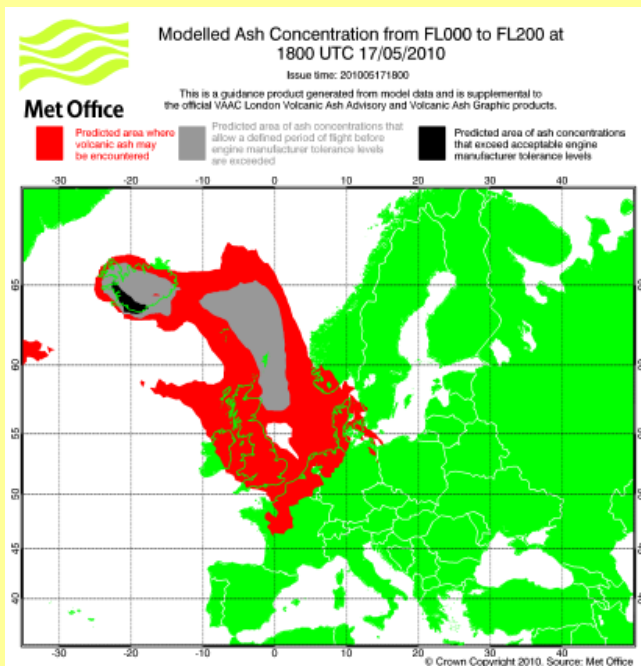
# Specific IVATF Recommendation

## —Ash Concentration Charts

New type of VAAC product introduced in Europe in 2010 that depicted modelled zones of ash concentrations.

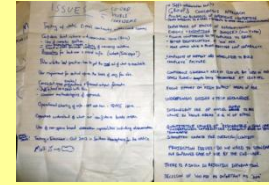
Through the Science Subgroup and VASAG, modelling experts & other scientists pointed out that:

- Concentration values as output of dispersion models have **uncertainty of at least an order of magnitude**, one major culprit being uncertainties in ESPs (especially erupted mass) used to initialize models.
  - 2 mg/m<sup>3</sup> contour could be 0.2 to 20 mg/m<sup>3</sup>
  - There is no meaningful difference between 2 & 4 mg/m<sup>3</sup>.
- Based on these scientific considerations, IVATF recommended that concentration charts **NOT** be the official product required by ICAO of all Volcanic Ash Advisory Centers.
- However, research must continue on the concentration concept, in parallel with more knowledge about engine and airframe tolerances.
- But where does that leave users operationally now?
  - still wanting more than current products with undefined cloud edges and complete ash avoidance.



# Specific IVATF Recommendation —VAAC “Best Practices”

- VAACs operate autonomously within each national structure, which has led to some differences in approach. To minimize unnecessary differences, IVATF recommended that:
  - VAACs specify **common best practices** for preparing advisory products, harmonizing SOPs to mitigate inconsistency for operators and regulators.
- 3 VAAC Best Practice Workshops held
  - Clarified procedures for ash clouds that cross VAAC boundaries.
  - Looked at how to communicate VAAC confidence in their products in a simple manner that operators can use.



- Also defined “Best Practices” to drive further specific changes in products:

The expert evaluation of the best available sources of meteorological and volcanological information:

qualitative and quantitative satellite data

model output

ground and airborne in-situ and remotely sensed observations

pilot reports

using (where possible) collaborative approaches to derive authoritative , high quality, **evidence-based and globally consistent** analysis and forecasts.

# Conclusion

- Post Eyjafjallajökull, there is broadly renewed interest in the issue of volcanic hazards to aviation.
- A globally coordinated effort—**which seeks and uses scientific input**—is in place to improve ash-hazard warning procedures and products, for the purpose of safe and efficient air travel.
- IVATF accomplished much, but the challenge remains to more accurately define and depict what constitutes hazardous airspace.
  - Unfinished/ongoing operational matters are handed off to ICAO's IAVWOPSG, while VASAG and broader scientific community are looked to for continuing relevant research.

**Onward – as we are doing here in Geneva!**